Parallelized Simulations of Tunnel Advancement using the Finite Cell Method

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ABSTRACT

The Finite Cell Method (FCM) can be used as an effective computational modeling tool during the design stage of tunnel construction projects, where the consequences of different scenarios and different tunnel alignments on the built environment are to be analyzed. For this purpose, efficient techniques for the generation of the computational models for the investigated design scenarios are required, without the need of changing the underlying computational mesh for each design variant. To accommodate that objective, the fictitious domain approach is used, where the boundary between the tunnel shell and the soil is resolved by means of adaptive quadrature and weakly imposed boundary conditions. The FCM computational model comprises of a structured mesh representing the ground that is fixed during the simulation of the tunnel advancement. The tunnel lining is modelled by means of finite shell elements. The soil is modelled as a fully saturated two phase material, consisting of the soil skeleton and the pore water. The elastoplastic Mohr-Coulomb constitutive model is used to reflect the stress-strain relation in the soil.

Since adaptive quadrature is used to capture the tunnel boundary, it quickly generates an excessive number of quadrature points, especially in 3D simulations. In this talk, several techniques are discussed to circumvent this problem, including quadrature reconstruction using moment-fitting-based techniques. Parallelized computing strategies are applied to speed-up the overall solution and distribute the memory consumption to a pool of computing nodes. The performance of the proposed model is demonstrated by the numerical analysis of the advancement of a straight tunnel in soft, saturated soil.

Keywords

Parallelization, Cut-cell quadrature, moment-fitting, finite cell method, tunnel engineering.

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